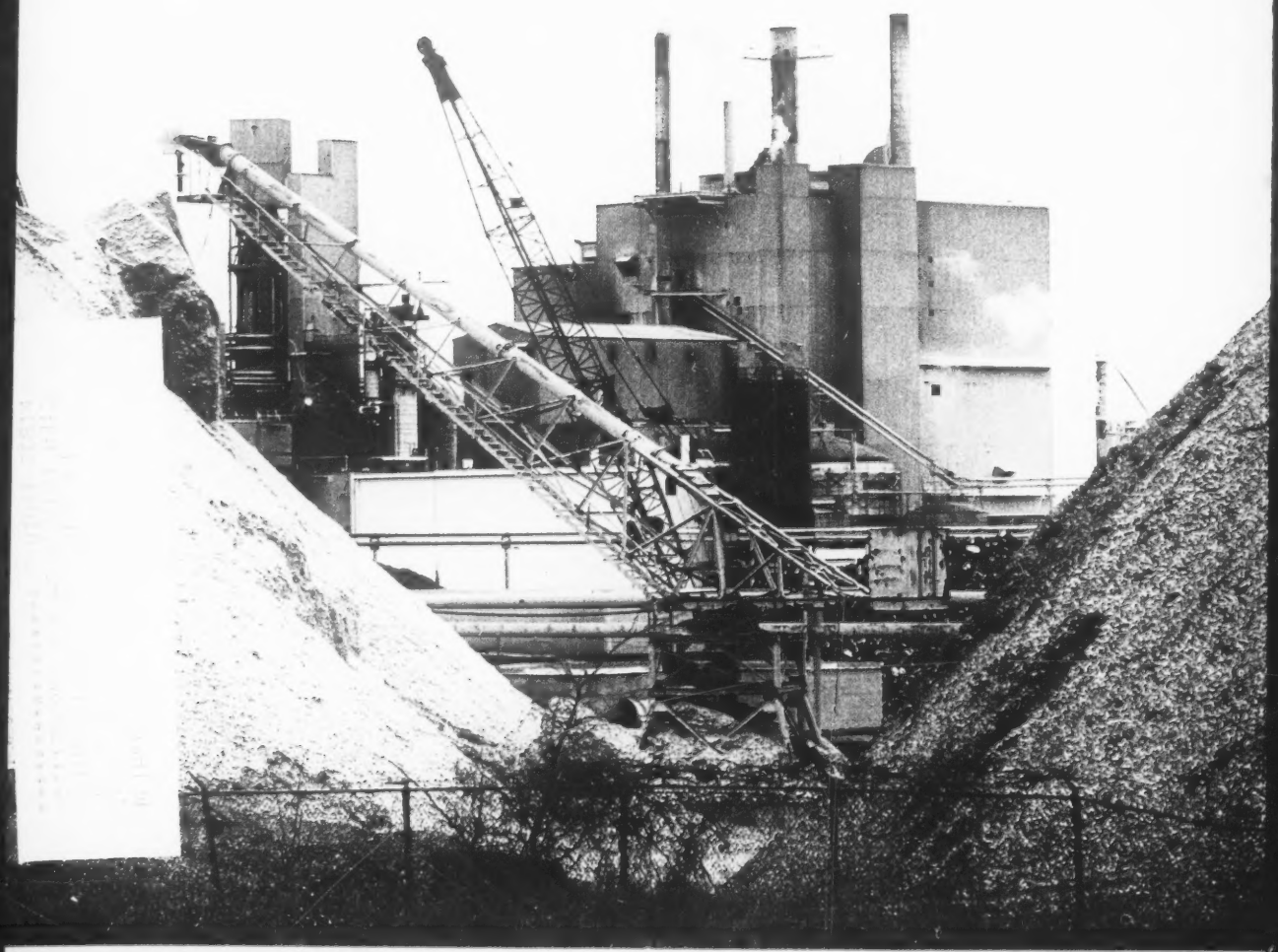
Scientific news from the Atlanta ACS meeting

APRIL 29, 1991

CHEMICAL & ENGINEERING

NEWS



Precipitated Calcium Carbonate

New uses in papermaking spark demand growth Page 9

CHEMICAL & ENGINEERING NEWS

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APRIL 29, 1991

News of the Week

■ **Report detailing 22 technologies considered critical to the U.S.'s future is issued by panel formed by White House Office of Science & Technology Policy under Congressional mandate.** Page 4

■ **In aftermath of castigation of Stanford for billing the federal government for inappropriate indirect research costs, universities scramble to review their accounts, and Office of Management & Budget issues tighter rules.** Page 5

■ **Iraq files letters describing its chemical, missile, and nuclear programs; U.S. says report is incomplete.** Page 5

■ **President Bush stresses his support for math and science education to educators attending summit on mathematics last week at the National Academy of Sciences.** Page 6

■ **Chemical operations will be hit hard in Olin reorganization that includes selling several chemical operations and eliminating 250 salaried positions, among them chemists.** Page 6

Cover: Pfizer's precipitated calcium carbonate plant at International Paper's mill in Ticonderoga, N.Y.

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Science/Technology

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ACS News

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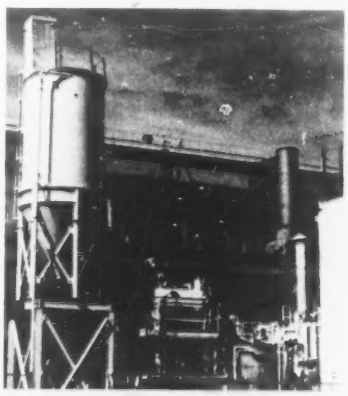

Business

Precipitated calcium carbonate is finding growing market as cost-saving mineral filler in longer lasting acid-free paper, accelerating transition from traditional acid paper. **Page 9**

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LETTERS

Approving new drugs

Ann M. Thayer wrote a cover story on biopharmaceuticals (C&EN, Feb. 25, page 27) in which the Food & Drug Administration's process for approving new drugs was described. She stated, "Upon completion of clinical trials, a product license application, as it is called by FDA's Center for Biologics Evaluation & Review, which handles biotechnology drug products, is filed."

We would like to draw to your attention that many biotechnology drug products are reviewed and regulated by the Center for Drug Evaluation & Research. These biotechnology drugs reviewed by the center include, among many others, superoxide dismutase, epidermal growth factor, human growth hormone, and human insulin as appeared in the list on page 32 of Thayer's article. For these products, a new drug application is filed with the Center for Drug Evaluation & Research for marketing approval. In fact, the new drug applications for human insulin and human growth hormone (the first two approved biotechnology products) were approved in 1982 and 1985, respectively.

Yuan-yuan Chiu
Chairman, Biotech Committee
Center for Drug Evaluation & Research
Food & Drug Administration, Rockville, Md.

Political environmentalism

Kudos to Charles M. Krutchen for his letter on polystyrene foam (C&EN, Feb. 11, page 38). Almost simultaneously, *Science* published Martin B. Hocking's excellent analysis, "Paper versus Polystyrene: a Complex Choice," in the Feb. 1 issue. Shortly after, A. Alan Moghissi (C&EN, Feb. 18, page 3) developed the terms "scientific environmentalist" as opposed to "political environmentalist," with reference to other environmental problems.

Taken together, these three articles stress the seriousness of letting political environmentalism continue to take its toll of sound chemical products such as polystyrene foam. Krutchen says that the "attack on polystyrene foam is really an attack on the chemical [and, I would add, the plastics] industry. . . . How many more chemical products will go down before the chemical industry finds effective means for defending itself?"

I would suggest that one counterattack would include the form of analysis presented by Hocking before and during the development of consumer products. Such analyses should then be advocated before and during the commercialization of such products. Then the scientific environmentalist may prevail over the political counterpart.

George W. Ingle
Hampden, Mass.

Are environmentalists our deadly nemesis, launching an all-out attack on the chemical industry, as stated so colorfully by Charles M. Krutchen? I believe that Krutchen's assertions are totally unfounded, particularly with respect to the specific case he highlighted: McDonald's decision to no longer use polystyrene "clamshell" containers. Along with other polystyrene advocates, Krutchen has grossly misinterpreted the results of the Franklin Associates report that he quoted to bolster his argument.

First, and most critically, the Franklin report specifically examines only two types of fast food clamshell containers: polystyrene (about 5 g per container) and paperboard (about 15 g per container) as used by several fast-food outlets. The goal is to determine the life cycle environmental impact, cradle to grave (so to speak): energy requirements, air and water discharges, industrial and consumer solid waste. The Franklin report finds polystyrene to be significantly superior to paperboard; McDonald's is not switching to paperboard, however. It is switching instead to a paper-based wrap (about 5 g per container) that is environmentally superior to polystyrene on all counts! Using figures calculated from the Franklin report, paper wrap uses 55% less energy in manufacture, and produces 45% less air and water discharge and 80% less consumer solid waste, relative to polystyrene. Krutchen, either knowingly or unknowingly, published serious disinformation in his letter.

Another misleading characteristic of the Franklin report is that their figures are for total input and output. For air emission, for instance, they lump together all emissions, making no attempt to accurately gauge health effects. Consider that benzene and styrene (both are toxic and carcinogenic) figure prominently in polystyrene air and water emissions, while ozone-depleting chlorofluorocarbons (CFCs) and now pentane hydrocarbons are used in polystyrene blowing. By contrast, unbleached paper wrap and paperboard emit mainly sulfur dioxide, nitrogen dioxide, carbon monoxide, and carbon dioxide. While these figure prominently in acid rain,

risk from exposure to TCDD, mostly by human consumption of fish that have levels of TCDD acquired by eating other, lower organisms.

It's possible that even if EPA changes the risk estimate for TCDD, its overall cancer risk might not change if the agency modifies its estimate of average fish consumption, a matter of some controversy itself. So the question of bioavailability of TCDD will be reviewed as well. Reilly has requested that all agency actions related to TCDD, either under way or planned, be checked for any appropriate changes while the special reassessment is in progress.

EPA is not going to do this activity single-handedly. Reilly has committed the agency to a wide open review. "It needs to be carried out with the broader scientific community," he says, "with a view toward assuring that our reassessment is accepted as objective." EPA will probably reach out to other federal regulatory agencies in an effort to build a consensus on this new toxicity model.

The EPA review will take place concurrently with a Congressionally ordered study of the same kind by the National Academy of Sciences. Although EPA has not taken NAS's activity into account, the two studies likely will overlap considerably. EPA is under the gun for some answers regarding TCDD and its timetable is quite tight, with Reilly asking for quarterly reports and a completed reassessment in a year. The NAS review is not under the same pressure and probably will take longer.

Several environmental activists have already expressed doubt about any EPA move that might make TCDD appear less dangerous. TCDD has long been named as one of the most toxic chemicals known to humans on the basis of its carcinogenicity to lab animals, and it would be somewhat of a blow to environmental organizations concerned with the regulation of toxic chemicals if animal tests were found to be not so reliable as these groups have been stating. Although TCDD may be a special case, it could force industry and EPA to reevaluate other chemicals.

David Hanson

NAS greenhouse gas report signals new stance

The prestigious National Academy of Sciences' new report, "Policy Implications of Greenhouse Warming," may mark a turning point in the U.S. response to the complex issue of global climate change. While acknowledging great uncertainties in both the science and economics of global warming, the report recommends taking action now to slow the accumulation of greenhouse gases in the atmosphere (C&EN, April 15, page 5).

That recommendation does not go beyond the conclusions of the United Nations-sponsored Intergovernmental Panel on Climate Change report that was completed last year. Nor does it surpass what several European countries have advocated for some years. But the new academy stance is a substantial shift from its 1983 position on the subject. And it endorses a much more aggressive approach to the problem than that currently espoused by the Bush Administration, which encourages greenhouse gas control measures only if they can be justified on other grounds.

"As is usually true for NAS reports, the report is significant less for any new ground it breaks than it is for whom is saying it," comments Alan Miller, director of the University of Maryland's Center for Global Change. "It is significantly different from the Administration stand. It clearly sends the message that there is a tremendous amount that can be done that would even save money."

In this case, "who is saying it" is the Committee on Science, Engineering & Public Policy (COSEPUP), a joint committee of NAS and its sister organizations, the National Academy of Engineering and the Institute of Medicine. The 126-page report, prepared by a "synthesis panel," presents the principal findings of three other COSEPUP panels that have been studying the issue for about two years at the request of Congress. Daniel J. Evans, former Governor of and Senator from Washington State, chaired the synthesis panel.

They concluded that increases in concentration of carbon dioxide, chlorofluorocarbons (CFCs), methane, and nitrous oxide likely will result in a rise in average global temperature of between 1 and 5 °C by early in the next century. Then, much like a recent report by the Office of Technology Assessment (C&EN, April 1, page 7), they evaluated the options available for reducing emissions of those gases. U.S. emissions could be cut 10 to 40% from 1990 levels at little or no expense, they find.

At a news conference where the report was unveiled, Evans described the measures recommended

Panel lists cheap ways to limit greenhouse gases

Mitigation option	Net cost of implementation	Potential emission reduction (millions of metric tons of CO_2 (or equivalent) per year)
Energy efficiency in buildings	Net benefit	900
Vehicle efficiency	Net benefit	300
Industrial energy management	Net benefit to low cost	500
Transportation system management	Net benefit to low cost	50
Power plant heat-rate improvements	Net benefit to low cost	50
Landfill gas collection	Low cost	200
Halocarbon-CFC usage reduction	Low cost	1400
Agriculture	Low cost	200
Reforestation	Low to moderate cost	200
Electricity supply	Low to moderate cost	1000

Note: Net benefit = cost less than or equal to zero, low cost = cost between $1.00 and $9.00 per ton of CO_2 equivalent, moderate cost = cost between $10 and $99 per ton of CO_2 equivalent

in the report as an "insurance policy" in the face of a real problem of as yet unknown magnitude. "Nobody knows for sure" what the consequences of not acting would be, he said. "We believe the time to act is now. A whole lot of people in San Francisco bought insurance the day after the earthquake. This set of insurance policies is a worthwhile one to make."

In addition to ways to reduce greenhouse gas emissions, the report recommends taking steps to prepare for a warmer climate and higher sea level. "Even with the most aggressive mitigation measures," Evans said, "we will not see a world where greenhouse gas concentrations would actually decrease. We're going to have to adapt."

To ease adaptation, the panel recommends a vigorous agricultural research program to ensure ample food. Water supplies should be better managed and water conservation encouraged. Construction projects should incorporate margins of safety in the face of an uncertain future. For example, building bridges higher above sea level now, rather than raising them later to accommodate rising water levels.

Another section of the report discusses so-called geoengineering options for fighting global warming, a set of untested technological fixes. They include adding iron to the ocean to stimulate growth of carbon-dioxide-absorbing phytoplankton and using lasers to break up CFCs in the atmosphere.

Also proposed are several ways of reducing temperature by screening sunlight. Among them are placing 50,000 100-km^2 mirrors in Earth orbit; launching billions of aluminized hydrogen balloons into the stratosphere; and burning sulfur in ships or power plants to form sulfate aerosols that would induce clouds.

The report recommends against taking any such actions now, but suggests they could end up being relatively inexpensive last-resort options if all else fails. More research and development is needed, the report says, to understand both the geoengineering options' potential to offset global warming and their possible side effects.

Pamela Zurer

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Mathematical Lumping Techniques Could Benefit Atmospheric Modeling

MIT engineer describes how "lumping" could simplify computational analyses, help forecasting of global warming and the global CO_2 balance

Joseph Haggin, C&EN Chicago

ATLANTA

A prominent chemical engineer has suggested that some of the techniques of mathematical lumping, long used in the chemical industry, might profitably be applied to the analysis of global warming problems. Taking some of the existing guesswork out of modeling computations could permit the development of policies that are more effective and more equitably applied.

Weather predictions in the short term and climate predictions in the long term are based on the use of atmospheric circulation models, explains James Wei, professor of chemical engineering at Massachusetts Institute of Technology. One commonly used model, he told the Division of Industrial & Engineering Chemistry, divides the atmosphere into 10 levels in the vertical direction, 22 divisions between the poles, and 36 around the equator. These divisions define about 8000 atmospheric cells that circulate over Earth and carry the weather with them.

The cells are not all the same size. The entire surface of the U.S., for example, is covered by only 10 cells, which are too large to permit very localized weather forecasting. Even so, to make a reasonable simulation of the atmosphere using these cells requires about 400 hours of computation time on a Cray-1 supercomputer.

The computational problem will probably get worse because, as Wei describes the problem, the "climate community" is already talking about a higher resolution of atmospheric cells—that is, more smaller cells—by making the present grid 10 times smaller. Computations using such a grid would require a 10-teraflop (10^{12} floating point operations per second) computer. If political policy decisions were ever to be based on data issuing from such a model, then the computational requirements would need to be even further extended to require a petaflop (10^{15}) computer. In the language of the chemical engineer, "simplifying assumptions are necessary" to reduce the problem to a more manageable form. One might be the employment of "lumping" techniques in analyses of atmospheric behavior in the future.

The basic idea behind lumping is the partitioning of variable space into a manageable number of states, invariably with the sacrifice of precision but with the virtue of computational manageability. Mathematicians have used the technique in the analysis of Markov chains and elsewhere. Wei and his associates applied the technique more than 20 years ago to the analysis of catalytic reforming processes in which a great number of molecular species were involved. In the physical world, lumping invariably involves less than ideal choices of "lumps," but the technique is no less valid because of that.

Wei has been investigating the problems of global warming and the global carbon budget. The problems are related but distinct. The first step that must be taken in solving them is to more precisely define them. This requires a better forecasting model than is now available. In the case of the anthropogenic emission of carbon dioxide, Wei notes that the atmosphere contains about 740 billion tons of CO_2 growing at a rate of about 3 billion tons per year, with the ocean absorbing another 3 billion tons. The prospect usually presented is that, if the atmospheric greenhouse gases double in concentration, the average temperature on Earth would increase 1.5 to 3.5 °C. This would probably have serious climatic effects in the next century.

The 5 billion people on Earth contribute to the 5 billion tons or so of CO_2 emitted each year. Additional deforestation and unenlightened land use may add an additional 2 billion tons. If Earth's population doubles, as some predict it will, then carbon emissions may become too great to tolerate.

Wei believes it clearly is nec-

C&EN staff photo

Wei: simplifying assumptions needed

Lumping system has nine economic categories

	Basic parameters of carbon emission			
	Population, millions	GNP ($ billion)	Energy consumption (10^{18} joules)	Carbon emission (billions of tons)
U.S. plus Canada	270	4,860	82	1.4
Upper income Eastern countries	170	2,380	20	0.3
Western Europe	337	4,380	54	0.7
U.S.S.R. plus Eastern Europe	372	2,600	73	1.4
Upper middle income countries	433	1,170	16	0.30
Lower middle income countries	610	730	12	0.20
India	798	240	7	0.15
China	1069	310	20	0.50
Others	957	270	7	0.15
TOTAL	5016	16,940	291	5.10

Note: 10^{18} joules, an exajoule, is 0.95 quadrillion Btu

essary to find a scheme not only for analyzing the atmospheric circulation, but also for lumping the sources and effects of carbon generation and consumption. How one does the lumping is debatable. The United Nations Environmental Program divides 100 of the world's nations into seven classes that are not very useful from the mathematical viewpoint. The U.S. Environmental Protection Agency uses another scheme that tends to lump nations by national wealth. And the World Bank divides 120 reporting nations into three income groups and doesn't include 10 nonreporting nations.

Wei has devised his own lumping system. It has nine economically designated categories: the U.S. and Canada; Eastern countries in the Organization for Economic Cooperation & Development plus other high-income Eastern countries; Western Europe; the U.S.S.R. and Eastern Europe; upper middle income; lower middle income; India; China; and other low income.

The larger emitters of CO_2 are evident, although for different reasons. The U.S., for example, simply consumes more fuel, but China is also a big emitter because of low combustion efficiency. Wei has developed some parametric ratios that are pertinent to his analysis, including $/P, the gross national product per capita; E/P, the energy intensity per capita; and C/E, the carbon intensity of energy use.

At any given time the rate of carbon emission is the product of these ratios and the population: C(t) = (C/E)(E/P)($/P)(P). Manipulation of and derivations from this equation are useful only if reliable data can be obtained in each country. This may be difficult to do. In any case, with Wei's model, the principal variables are national wealth, population pressure, energy intensity, and carbon intensity in energy use. Not everyone agrees with this suggestion. If the lumping scheme is good, says Wei, then the four growth rates for the variables would behave uniformly in each region. This may be a difficult requirement to impose, even within a single nation.

The eventual need for enlightened public policies will require the best possible model of the atmosphere and the carbon balance. Every decision will cost money, force changes in life-styles, and produce other effects on the populations of the nations. Among other things, policies that are optimum would be based on hard data. Anything else would be a guess.

It seems clear that each policy decision should target some form of carbon reduction, and there must be incentives to impose it. Above all, Wei says, the costs must not exceed the anticipated benefits. It is equally clear that there may be changes in societal behavior, in technology, or in both. Wei sees four driving forces effecting the anticipated changes, one related to each of the four ratios mentioned above.

Maintaining or lowering the present population is the most controversial of the possibilities. Personal morality plays a key role, and it is not clear who will accept or reject this alternative. Deliberately checking economic growth is equally controversial and would require superhuman statesmanship, which probably doesn't exist. Both of these changes are purely societal, but there are two more that are equally technical. One is changing the energy intensity of a nation through conservation, increased efficiency, and substitute energy sources. The potentials here are very great. Finally, it may be necessary to change the carbon intensity of energy use by decreasing the use of fossil fuels. The obvious things are employment of nuclear energy, hydro-energy, tides, wind, and the like. Biomass may be a useful fuel, if the rate of burning doesn't exceed the rate of reforestation.

Among the proposals that have been made in this respect is the use of energy transfer payments between nations. It may be more cost-effective for Sweden and the Netherlands, for example, to pay for more efficient furnaces in Poland than to incrementally improve their own, which are already rather efficient. Rich nations that emit more carbon oxides than poor ones would have the same emissions quota nonetheless. An effective transfer of payments might result if the rich nations could buy emissions permits from the poorer ones. This raises numerous political problems, however, since the poorer nations might thereby be encouraged to further increase their already bulging populations to acquire still more permits. Still, Wei believes that this is a solvable problem.

In the last analysis, there is a prime need for a reliable model for atmospheric operation and the global carbon budget, among other things. These will remain intractable problems until some lumping scheme is developed that can reasonably function on available computers. Wei's scheme is one of many that will be offered, but it does suggest that the seemingly intractable problem may not be so intractable after all. □